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FIRE GROWTH RATES IN STRUCTURAL FIRES

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N2L 361

Introduction

The work reported in this paper represents one aspect of a cooperative project between the City of Kitchener Fire Department and the University of Waterloo aimed at developing design criteria for the construction of a fire fighter training facility. One particular criterion is that realistic training with respect to temperature, heat release and stratification be provided in such a facility. It is the purpose of this paper to compare existing analytical heat release and upper and lower layer gas temperature rise correlations and models with data from actual structures which were instrumented and burned in collaboration with the Kitchener Fire Department.

Description of the Models

The three mathematical models used in the prediction of the upper layer gas temperature rise were the ASET-B model as implemented in FPEtool, available through NIST [1], correlations of previous fire test data put forth by McCaffrey, Quintiere and Harkleroad [2], and the CFAST programs, also available through NIST [3]. The temperature rise in the lower layers of the rooms were also predicted using the CFAST programs. The inputs to the models include the physical room dimensions, the ventilation opening geometry, the thermophysical properties of the interior enclosure lining materials, the properties of the ambient air, and the transient heat release rate (HRR) from the fire.

Instrumentation and Experimental Conditions

The data base used for testing the correlations was obtained from full scale structural fire tests in which the temperature profiles of the upper and lower gas layers in selected rooms were recorded during development of a room fire. The fires were initiated in rooms of differing sizes, lining materials and fuel loadings in order to test the ability of the models to predict over a variety of inputs. For practicality, the test fires were allowed to develop only until the environment in the structure became too severe to allow entry of fire fighters, as indicated by measured lower zone gas temperatures. Computations were also truncated on this basis. Room lining materials included concrete, concrete block, wood panelling, plywood, and gypsum plaster. The fuels used in the tests were wooden pallets, liquid hydrocarbon fuels and polyurethane foam mattresses. The fires were non-ventilation controlled. Thermocouples were located at several positions on the ceiling and at the fire fighter level (FFL, one metre above floor) throughout the rooms. Heat release rates from the fuels were estimated for the wooden pallets, polyurethane foam mattresses and diesel fuel using models presented by Delichatsios [4], Orloff [5], Stensaas, Hovde and Magnussen [6] and Weckman [7] respectively, as appropriate.

Results

The measured and predicted upper and lower layer gas temperatures for typical tests are shown in Figures 1 and 2. Good agreement between the measured data and the predictions of the models is found for the temperature rise at the ceiling in the upper zone. The CFAST subroutines show fair agreement between the measured and predicted temperatures of the lower zone.

The sensitivity of the models to variations in the input parameters has been examined. Thomas and Bullen [8] have shown that the thermal properties, i.e. density, specific heat and thermal conductivity, of the interior enclosure lining materials have little effect on the time to reach critical conditions in the enclosure. The effect of varying the ventilation opening geometry and heat release rate from the fuel were examined and show that the models are extremely sensitive to the heat release rate predictions and moderately sensitive to the ventilation opening geometry.

Conclusions

As the models discussed in this paper have generally been tested under controlled laboratory conditions, there **is** a need to develop confidence in their ability to predict the conditions which exist in an uncontrolled environment. Given that the HRR of the fuels under consideration can be reasonably estimated, both the ASET-B and CFAST models, and the test fire data correlations demonstrate good agreement with the measured data and can be used with confidence for estimating the temperature **rise** in the upper layer of a room during the initial stages of a developing fire, at a minimum until such time that the environmental conditions within the structure become too severe to allow the entry of fire fighters. The ability to predict the HRR and temperature rise in a full scale structural fire finds application **as** a design tool for the development of a safe and realistic training facility. The results of this comparison also provide real fire validation **of** these models which in turn are also applied **to** fire protection engineering (pre-fire planning), fire cause determination and risk assessment.

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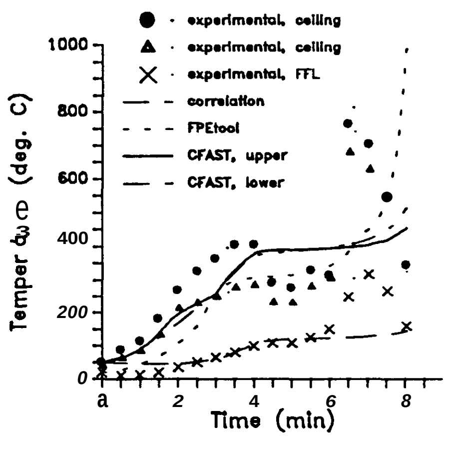

FIGURE 1

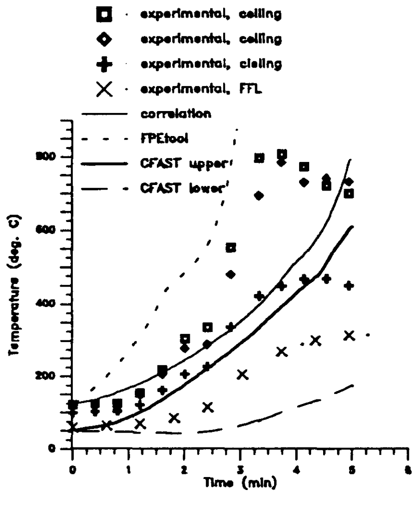

FIGURE 2